Original Article

Comparison of hemodynamic and metabolic stress responses caused by endotracheal tube and Proseal laryngeal mask airway in laparoscopic cholecystectomy

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Background: We aimed to compare hemodynamic and endocrine alterations caused by stress response due to Proseal laryngeal mask airway and endotracheal tube usage in laparoscopic cholecystectomy. **Materials and Methods:** Sixty-three ASA I-II patients scheduled for elective laparoscopic cholecystectomy were included in the study. Patients were randomly allocated into two groups of endotracheal tube and Proseal laryngeal mask airway. Standard general anaesthesia was performed in both groups with the same drugs in induction and maintenance of anaesthesia. After anaesthesia induction and 20 minutes after CO_2 insufflations, venous blood samples were obtained for measuring adrenalin, noradrenalin, dopamine and cortisol levels. Hemodynamic and respiratory parameters were recorded at the 1st, 5th, 15th, 30th and 45th minutes after the insertion of airway devices. **Results:** No statistically significant differences in age, body mass index, gender, ASA physical status, and operation time were found between the groups ($p > 0.05$). Changes in hemodynamic and respiratory parameters were not statistically significant when compared between and within groups ($p > 0.05$). Although no statistically significant differences were observed between and within groups when adrenalin, noradrenalin and dopamine values were compared, serum cortisol levels after CO_2 insufflation in PLMA group were significantly lower than the ETT group ($p = 0.024$). When serum cortisol levels were compared within groups, cortisol levels 20 minutes after CO_2 insufflation were significantly higher (46.1 (9.5-175.7) and 27.0 (8.3-119.4) in the ETT and PLMA groups, respectively) than cortisol levels after anaesthesia induction (11.3 (2.8-92.5) and 16.6 (4.4-45.4) in the ETT and PLMA groups, respectively) in both groups ($p = 0.001$). **Conclusion:** PLMA usage is a suitable, effective and safe alternative to ETT in laparoscopic cholecystectomy patients with lower metabolic stress.

Key words: Endotracheal Tube, Proseal Laryngeal Mask Airway (PLMA), Hemodynamic Response, Metabolic Response

INTRODUCTION

Surgical trauma causes reaction and damage in the organism in proportion to the extent of the operation. Triggering the physiologic mechanism off causes local inflammation and hypermetabolism process due to the general substrate mobilization and accelerated biochemical reaction.[1] It is also associated with complex stress response characterized by neuro-humoral, immunological and metabolic alterations.[2] Activation of sympathetic nervous system and increased release of catabolic and immuno-suppressive pituitary hormones can be attributable to surgical stress response.[3] In clinical practice, these activations cause changes in heart rate and blood pressure and alterations in biochemical measurements like noradrenalin, adrenalin, dopamine and cortisol levels. The type of surgical procedure, either open or laparoscopic, reflects the severity of traumatic stress imposed to the organism. Open surgery may develop much more stress than laparoscopic surgical procedures due to long surgical time, big surgical incision and local and systemic effects.[2,4,5]

Endotracheal intubation has been demonstrated to impose the most intense stress to organism under general anaesthesia.6,7 Proseal laryngeal mask airway (PLMA), a supraglottic airway device, is a modification of classical laryngeal mask airway (LMA) which was introduced to clinical practice in 2000. Having a gastric drainage system to provide a channel for regurgitated fluid, named gastric tube placement, and thus preventing gastric insufflation is the major difference between PLMA and classical LMA. PLMA is considered to cause minimal stress response as it is a supraglottic device, less invasive, used without muscle relaxants and used in short procedures.[8,9]

In this study, we aimed to compare hemodynamic and metabolic alterations caused by stress response due to PLMA and endotracheal tube (ETT) usage in laparoscopic cholecystectomy.

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MATERIALS AND METHODS

After approval of the Ethics Committee and obtaining patients' informed consents, 63 ASA I-II patients, aged between 20-70 years scheduled for elective laparoscopic cholecystectomy, were included in the study. Exclusion criteria were a known or predicted difficult airway, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, cardiac disease, history of allergic reaction, history of corticosteroid drug usage, and body mass index greater than 35 kg/m^2.

Forty-five minutes before operation, 0.07 mg/kg intramuscular midazolam was given to the patients. Routine monitoring including electrocardiogram, noninvasive blood pressure and pulse oximetry were applied to each patient in the operating room. Standard general anaesthesia was performed in both groups by using 4-7 mg/kg sodium thiopental, 1-2 μg/kg fentanyl citrate and 0.1 mg/kg vecuronium bromide during induction. Patients were randomly allocated into two groups. Randomization was performed before anaesthesia by using a sealed opaque envelope with a computer-generated block random allocation. In the ETT group (n = 31), endotracheal intubation was performed. Endotracheal tubes numbers 7 and 7.5 were used in females and numbers 8 and 8.5 in males. ETT placement was defined as difficult if a guide was used or if cricoid pressure was applied. The cuff pressure of ETT was maintained in a range of 25-30 cm H_2O by using a cuff manometer.

In the PLMA group (n = 32), PLMA (Laryngeal Mask Company, Henley-on-Thames, UK) was inserted by using index finger insertion method. PLMA 3 and 4 were used in females and PLMA 5 in males. PLMA insertion was defined as easy if insertion within the pharynx was completed without resistance through a single manoeuvre. However, in case of any resistance to insertion or more than one necessary manoeuvre, the procedure was considered as difficult. The position of PLMA was confirmed by bilateral chest movements, a square waveform on capnography, chest auscultation, expired tidal volume > 8 ml/kg and insertion of nasogastric tube and aspiration of gastric contents. The cuff pressure of PLMA was maintained at 60 cm H_2O.

ETT and PLMA insertions were performed by the same anaesthetist who had an anaesthetic experience more than 3 years and had successfully used classical LMA more than 500 times and PLMA for at least 100 times. Sevoflurane 1-2% and 50% NO_2 + 50% O_2 were used in the maintenance of anaesthesia. Patients were mechanically ventilated with a tidal volume of 8 ml/kg and a respiratory rate of 12 beat/min. Oxygen saturation (SpO_2) and end-tidal carbon dioxide ($EtCO_2$) were adjusted to > 95% and < 45 mmHg, respectively. If SpO_2 < 95%, the fraction of inspired oxygen (FiO_2) and tidal volume were increased respectively. If $EtCO_2$ > 45 mmHg, respiratory rate was increased. Intra-abdominal pressure was maintained < 15 mmHg during the operation. Mean arterial blood pressure (MAP), heart rate (HR), SpO_2, airway pressures especially peak airway pressure, $EtCO_2$ and tidal volume were recorded at the 1st, 5th, 15th, 30th and 45th minutes after the insertion of airway devices. Side effects like bronchospasm, laryngospasm, coughing, gagging, hoarseness, and aspiration were also evaluated. Hemodynamic alterations like hypotension (> 25% decrease in MAP from the baseline), hypertension (> 25 % increase in MAP from the baseline), tachycardia (heart rate > 120 beat/min), and bradycardia (heart rate < 50 beat/min) were recorded during the operation and manipulated by titration of inhalation anaesthetics at 0.5% concentrations, volume infusion and administration of intravenous 0.5 mg atropine sulphate.

After induction of anaesthesia and 20 minutes after CO_2 insufflation, venous blood samples were obtained for measuring adrenalin, noradrenalin, dopamine and cortisol levels. Blood samples were centrifuged immediately and plasmas were stored at -80°C until hormonal analysis. For analyzing catecholamine levels, high pressure liquid chromatography (HPLC) method was applied using Eureka kits (Enrico Fermi 25 60033 Chiaravalle (An) Italy). Serum cortisol levels were measured by Modular Analytics E170 Module (Roche Diagnostics, Indianapolis, USA). Cortisol levels were measured in 10 patients of each group before the procedure and the values were found to be 17.74 ± 13.8 in the ETT and 16.03 ± 12.6 in the PLMA groups. Therefore, with a 100% increase in the ETT and a 50% increase in the PLMA groups, a preliminarily sample size of 25 patients per group with a type 1 error of 0.05 and a type 2 error of 0.20 was calculated.

Statistical analyses was performed by $SPSS_{11.5}$ (Statistics Package for Social Sciences) for Windows. Data was presented as mean ± standard deviation, median and frequency (%). Comparisons between groups were performed by unpaired student t-test and Mann-Whitney U-test for continuous variables and chi-square test for intermittent variables. Paired sample t-test and Wilcoxon test were used for comparisons within each group. A p value less than 0.05 was considered as statistically significant.

RESULTS

No statistically significant differences were found between the groups when demographic data was taken

into account ($p > 0.05$) (Table 1). Duration of operation was 46 ± 11.26 minutes and 45.43 ± 13.78 minutes in the ETT and PLMA groups, respectively ($p = 0.875$). ETT number 7 was placed for 7, number 7.5 for 20 and number 8.5 for 8 patients. PLMA size 3 was inserted for 19, size 4 for 11 and size 5 for 2 patients. First attempt success rate was 90.32% and 93.75% in the ETT and PLMA groups, respectively. Second attempt success rate was 9.645 in the ETT group and 6.25% in the PLMA group. Respiratory parameters like SpO_2, peak airway pressure, $EtCO_2$, and tidal volume were not statistically significantly different when compared between and within groups at all evaluation times ($p > 0.05$) (Table 2). Peak airway pressures were slightly increased in both groups after carboperitoneum, but it did not disrupt ventilation. Ventilation was optimal (EtCO2 < 45 mmHg) in all patients in both groups before and after CO_2 insufflation.
Changes in hemodynamic parameters were not statistically significant when compared between and within groups at all evaluation times ($p > 0.05$) (Table 3).

Although no statistically significant difference was observed between and within groups when adrenalin, noradrenalin and dopamine values were compared, serum cortisol level after CO_2 insufflation in the PLMA group was significantly lower than the ETT group ($p = 0.024$) (Table 4). When serum cortisol levels were compared within groups, cortisol levels 20 minutes after CO2 insufflation were significantly higher than cortisol levels after anaesthesia induction in both groups ($p = 0.001$) (Table 5).

Table 1. Demographic parameters

Parameter	ETT group (n = 31)	PLMA group (n = 32)
Age (year)	47.84 ± 13.41	46.19 ± 10.62
BMI (kg/m^2)	28.71 ± 3.61	28.97 ± 5.75
Gender (Female/Male)	27/4	30/2
ASA physical status (I/II)	25/6	26/6
Operation time (minute)	46.56 ± 11.26	45.43 ± 13.78

Data is expressed as mean ± SD or numbers.
BMI: Body mass index
ASA: American Society of Anaesthesiologists
ETT: Endotracheal tube
PLMA: Proseal laryngeal mask airway

Table 2. Respiratory parameters

	SpO2 (%)		PEAK (cm H2O)		EtCO2 (mmHg)		TV (ml)	
	ETT	PLMA	ETT	PLMA	ETT	PLMA	ETT	
1st min	98.87 ± 1.14	99.22 ± 0.97	18.55 ± 4.27	18.91 ±4.81	30.39 ± 3.49	32.25 ± 2.51	539.52 ± 48.32	552.03 ± 54.78
5th min	98.90 ± 1.20	99.30 ± 0.90	18.60 ± 4.20	18.95± 4.82	32.06 ± 2.06	32.18 ± 1.97	520.74 ± 33.29	534.93 ± 42.64
15th min	98.19 ± 1.06	98.53± 1.19	19.64 ± 3.12	19.05± 3.78	31.83 ± 2.60	32.31± 2.49	544.29 ± 38.16	545.18 ± 38.51
30th min	98.86 ± 1.78	98.15 ± 1.10	19.54 ± 4.81	19.90± 4.18	32.90 ± 2.13	33.34 ± 1.67	546.16 ± 49.96	537.06 ± 44.94
45th min	98.61 ± 1.33	98.94 ± 1.04	22.84 ± 3.96	22.03± 5.37	31.65 ± 3.42	31.72 ± 2.51	539.68 ± 62.52	541.88 ± 54.59

Data is expressed as mean ± SD.
ETT: Endotracheal tube
PLMA: Proseal laryngeal mask airway
SpO_2: O_2 saturation
$EtCO_2$: End-tidal CO_2 pressure
PEAK: Peak airway pressure
TV: Tidal volume

Table 3. Hemodynamic parameters

	Mean arterial pressure (mmHg)			Heart rate (beat/min)		
Time (min.)	ETT	PLMA	p	ETT	PLMA	p
1	100.26 ±13.68	101.00 ±17.62	0.853	81.77 ± 14.08	83.50 ± 8.34	0.555
5	100.16 ± 11.52	101.05 ± 15.72	0.850	82. 70 ± 14.05	83. 47 ± 8.20	0.520
15	101.08 ± 13.21	101.85 ± 15.17	0.921	86. 14 ± 10.08	85. 72 ± 11.12	0.570
30	101.98 ± 46.12	98.18 ± 10.32	0.456	88.78 ± 14.38	89.24 ± 16.52	0.457
45	102.26 ±16.19	94.63 ± 22.84	0.132	79.23 ± 14.60	79.69 ± 10.81	0.887

Data is expressed as mean ± SD.
ETT: Endotracheal tube
PLMA: Proseal laryngeal mask airway

Table 4. Comparison of stress hormones between groups

Parameter	ETT	PLMA	p
Adrenalin 1	73 (4-515)	85.5 (3.7-210)	0.601
Noradrenalin 1	261 (85-818)	288.5 (89-1297)	0.514
Dopamine 1	30 (7-369)	35 (13-501)	0.458
Cortisol 1	11.35 (2.84-92.56)	16.65 (4.41-45.45)	0.111
Adrenalin 2	48 (5-377)	67.5 (8-206)	0.853
Noradrenalin 2	266 (59-1121)	263.5 (103-2076)	0.700
Dopamine 2	38 (2-214)	27.8 (3.3-414)	0.541
Cortisol 2	46.1 (9.56-175.7)	27.08 (8.32-119.4)	0.024*

Data is expressed as mean (range).
ETT: Endotracheal tube
PLMA: Proseal laryngeal mask airway
1: After induction of anaesthesia
2: 20 minutes after CO2 insufflation
*: Statistically significant

Table 5. Comparison of stress hormones within groups

	ETT Group			PLMA Group		
Parameter	1	2	p	1	2	p
Adrenalin	7 (4- 515)	48 (5- 377)	0.784	85.5 (3. 7- 210)	67.5 (8- 206)	0.992
Noradrenalin	261(85- 818)	266 (59- 1121)	0.322	288.5 (89- 1297)	263.5 (103- 2076)	0.808
Dopamine	30 (7- 369)	38 (2- 214)	0.799	35 (13- 501)	27.8 (3. 3- 414)	0.317
Cortisol	11.3 (2.8- 92.5)	46.1 (9.5- 175.7)	0.001*	16.6 (4.4- 45.4)	27.0 (8.3- 119. 4)	0.001*

Data is expressed as mean (range).
ETT: Endotracheal tube
PLMA: Proseal laryngeal mask airway
1: After induction of anaesthesia
2: 20 minutes after CO2 insufflation
*: Statistically significant

DISCUSSION

Achieving a safe and effective airway is the principal aim of the anaesthesiologists. During laparoscopic cholecystectomy, safe airway management is necessary because intrathorasic pressure increases due to increased intra-abdominal pressure, gastroesophageal and biliary reflux which may in turn be a result of obesity and chronic systemic illnesses of the patients.

ETT is considered as the safest anaesthetic procedure for laparoscopic cholecystectomy. However, it has also some intraoperative and postoperative disadvantages like laryngospasm, hoarseness, and sore throat. In addition, supraglottic compression during laryngoscopy procedure increases systolic and diastolic blood pressure.[9]

Maltby et al. postulated that laparoscopic surgery was an important test for evaluating the effectiveness of supraglottic airway devices which were used in positive pressure ventilation.[10] It is already known that LMA is not safe in some procedures like laparoscopic cholecystectomy, as the patients have high intra-abdominal pressure which may cause gastroesophageal reflux and aspiration. Lu et al. compared PLMA and LMA in laparoscopic cholecystectomy patients and found PLMA to be a more effective ventilatory device for laparoscopic cholecystectomy than LMA. They did not recommend LMA for laparoscopic cholecystectomy.[11]

Evans et al.[12] and Keller et al.[13] researched whether PLMA could prevent the aspiration of regurgitated fluid or not. They found that a correctly placed PLMA allowed fluid in the esophagus to bypass the pharynx and mouth when the drainage tube was open and thus provided a safe airway management.

According to the recommendations of the abovementioned studies, we preferred to use PLMA in the current study to gain a safe and intact airway. We inserted nasogastric drainage tube in our PLMA and ETT groups and did not observe gastric distension and aspiration of gastric content due to gastric regurgitation in any patient of our study.

Lalwani et al. evaluated PLMA as an alternative to ETT in pediatric patients for short duration surgical procedures. They found hemodynamic responses to insertion of PLMA to be lower than ETT.[14]

Piper et al. compared PLMA and ETT in gynaecologic laparoscopies and concluded that PLMA was a safe and effective ventilation device with low stress imposed to patient and low occurrence of pharyngeal and laryngeal complications.[15]

Lim et al. compared PLMA and ET intubation on laparoscopic gynaecologic procedures and concluded that PLMA as effective as ETT with an attenuated hemodynamic response.[16]

In a multicenter study, Evans et al. found that PLMA caused no detectable responses to insertion and heart rate and mean arterial pressure decreased after insertion.[17]

In the current study, no adverse changes in hemodynamic variables were seen in either group. Although mean arterial blood pressure slightly increased in some of the patients in the ETT group after laryngoscopy, these increases were not statistically significant.

Maltby et al. assessed if LMA and PLMA were good alternatives to ETT in laparoscopic gynaecology procedures with respect to pulmonary ventilation. There were no statistically significant differences among the groups for SpO_2, $EtCO_2$, and airway pressure before or during peritoneal insufflation. They recommended that ETT could safely be substituted with correctly placed LMA and PLMA in gynecologic laparoscopy.[10]

Lalwani et al. found no significant differences in SpO_2 and $EtCO_2$ levels between their PLMA and ETT groups in pediatric patients.[14] Sinha et al. compared ETT and PLMA in pediatric laparoscopy patients by means of $EtCO_2$, peak inspiratory pressure and SpO_2. They did not report any statistically significant differences in SpO_2, $EtCO_2$ and positive inspiratory pressure between the groups. They concluded that the two devices had comparable ventilator efficacy in laparoscopic pediatric surgeries.[18]

Similar to the above research, synchronous evaluations of SpO_2 and $EtCO_2$ levels affecting hemodynamic and stress responses were not significantly different between the groups in our study. Although increases in $EtCO_2$ levels after CO_2 insufflation were seen in both groups, they did not cause considerable changes in hemodynamic parameters. $EtCO_2$ increased in the PLMA group similar to the ETT group which indirectly implied PLMA to be as efficient airway device as ETT.

In our study, we administered the same drugs in both groups. Since comparison of the effects of anaesthetic agents on stress hormones was not our aim, we did not assess the effects of drugs. Although general anaesthesia was performed to all of our patients, increases in cortisol levels were significantly lower in the PLMA group than in the ETT group. Therefore, the important factor was not the general anaesthesia but the way it was applied.

Walder and Aitkenhead evaluated if pneumoperitoneum affected hemodynamic and stress responses in laparoscopic cholecystectomy patients. They observed that although plasma vasopressin concentration significantly increased during pneumoperitoneum, noradrenalin and adrenalin concentrations, and renin activity did not change with pneumoperitoneum.[19] CO_2 insufflation for pneumoperitoneum in long periods may cause stress hormone increase due to CO_2 diffusion. In our study, mean duration of operation was nearly 45 minutes in both groups. Therefore, it is considered that the reason of increase in cortisol level only in the ETT group was not CO_2 insufflation. Lentschener et al. found that both humoral and hemodynamic responses initiated in the pneumoperitoneum by contact with CO_2 have been prevented by continuous adequate depth of anaesthesia and normovolaemia.[20]

In the current study, the patients were operated in elective circumstances and depth of anaesthesia and volume were controlled easily and strictly so humoral and hemodynamic responses caused by pneumoperitoneum were lower than the estimations. We observed an increase in serum cortisol levels in the PLMA group after CO_2 insufflation. In addition, cortisol levels 20 minutes after CO_2 insufflation were significantly higher than the first measurements in both groups. As dopamine, adrenalin and noradrenalin have short duration of activity with the plasma half time shorter than 2 minutes, they were not efficient enough for reflecting the metabolic stress response in our study. Thus, more sensitive new parameters and challenges need to be considered in addition to present laboratory tests.

CONCLUSION

Correctly placed PLMA is an efficient and safe airway option to ETT in laparoscopic cholecystectomy operations with lower incidence of metabolic stress responses and postoperative complications.

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